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Katelynne Knight  
kakn4094@colorado.edu

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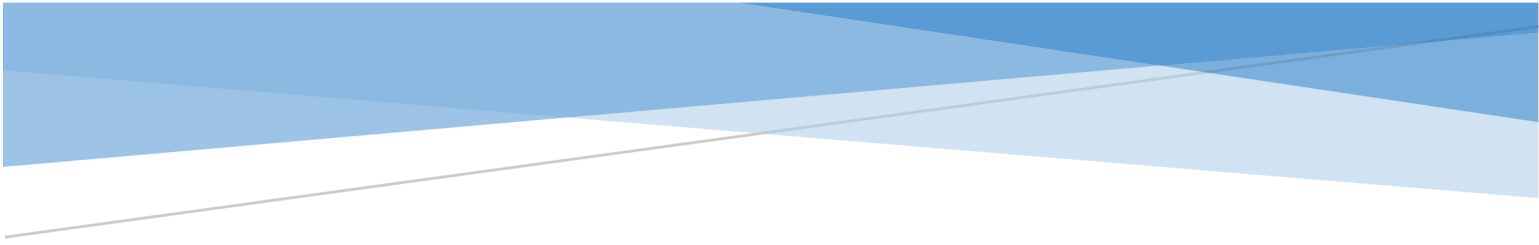
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# CURRENT CONDITIONS AND FUTURE FLOOD POLICY RECOMMENDATIONS FOR THE ST. VRAIN WATERSHED THROUGH A HISTORICAL HYDROLOGIC ANALYSIS OF THE TOWN OF LYONS, COLORADO

Katelynne Knight  
Submission for Honors  
Department of Geography  
University of Colorado, Boulder  
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Thesis Advisor:  
Dr. Paul Lander, Dept. of Geography

Defense Committee:  
Dr. Paul Lander, Dept. of Geography  
Dr. William Travis, Dept. of Geography  
Dr. Deserai Anderson Crow, Dept. of Environmental Studies

## **Abstract:**

At the merger of the North and South Saint Vrain Creeks is the settlement point for 1,915 people, making up the Town of Lyons, Colorado. As early as 1864 there have been observations and damage due to floods within the town limits. As a result, land use policies and other methods of flood prevention have played a roll in Lyons' development throughout the years, including the devastating floods of 2013. This paper seeks to find how over 100-years of flood events has influenced current land use policy in the Town of Lyons, as well as, future policy recommendations as a function of historic hydrologic events.

## **Key Words:**

Floodplain management, Historical hydrology, Socio-hydrology, Lyons Colorado

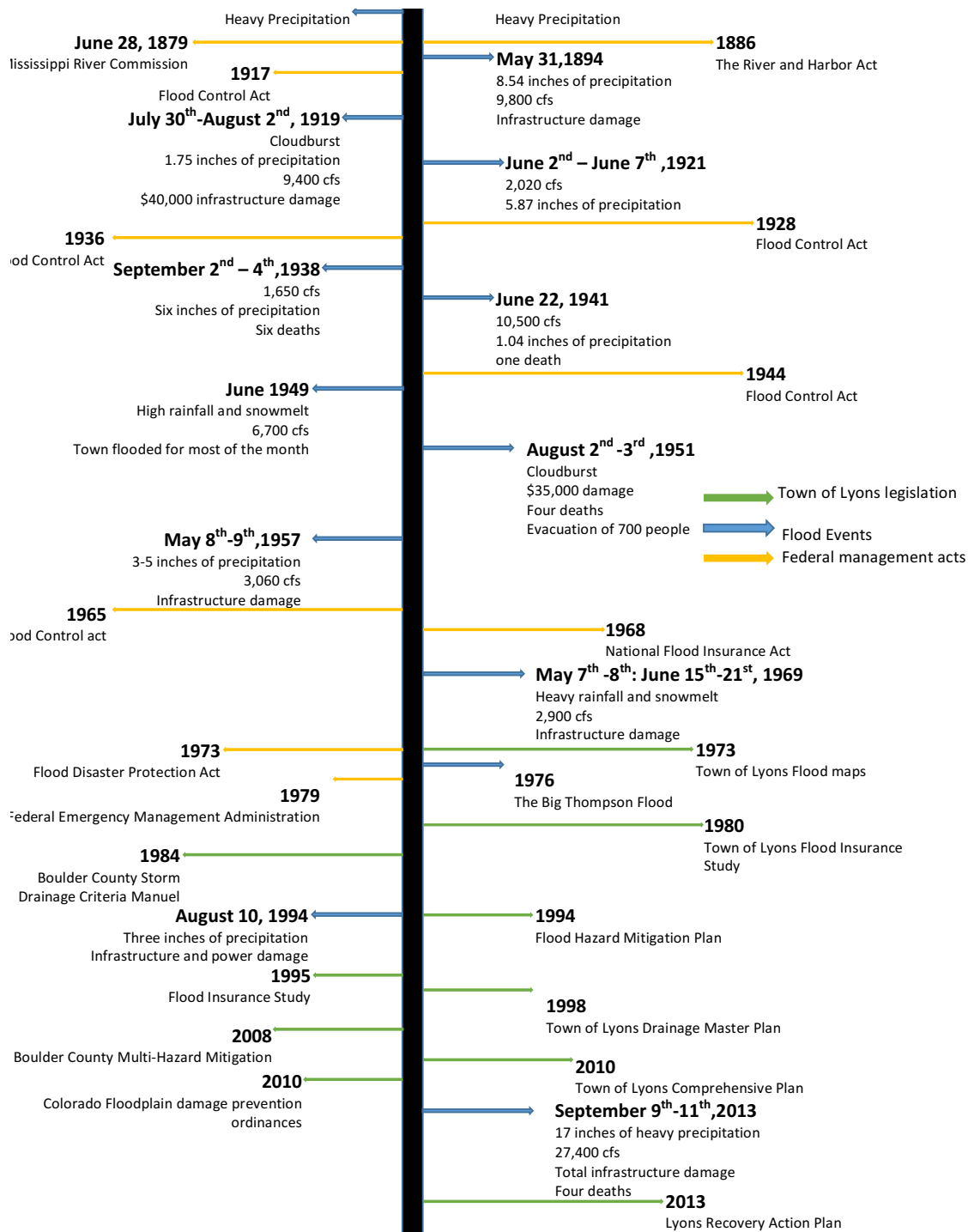
## **Introduction**

2013 was a destructive and expensive year across the United States for governments and communities impacted by floods. On January 10, 2013, Louisiana experienced flooding that amassed total damages of \$238 million. The week of April 15, 2013, left the Midwestern United States devastated after experiencing a similar flood event that left \$465 million worth of damage in its wake. The Front Range of Colorado experienced \$715 million of flood damage after over 17 inches of rain fell the week of September 12, 2013 (NOAA 2013). All of these events totaled \$2.15 billion in damage incurred from flooding and damaged neighborhoods all over the country. One of these communities is Lyons, Colorado.

Nestled into the Front Range of Colorado, the town of Lyons, is a small incorporated town of Boulder County and is currently home to 2,033 people (Lyons “About the”). In the floods of 2013, 75 homes were destroyed, and in the 18 months after the floods, 170 people (almost 10 percent of the population) have been unable to return home (Illescas 2015). While Lyons was severely damaged during the 2013 flooding it was not the first time the small town had come face to face with the implications of living in a floodplain, and it certainly will not be the last.

Humans have existed in floodplains for hundreds of years. Whether it is the draw of a scenic view or because of industry, living next to a creek or river seems like a perfect life for many people. However, life next to a creek, may also involve havoc and destruction. The interactions people have with floodplains is an interesting relationship that gives way to the implementation of floodplain management. These governmental measures are often a culmination of many different fields of study, and they help enable communities to coexist in fertile floodplains.

Since the town of Lyons was incorporated in the late 1800's, the town has had to recover from floods that have devastated the community, and shaped the way people interact with floods. This investigation helps to identify how the town has adapted in the face of floods and contributed to always improving floodplain management theories. As demonstrated in Figure 1, this examination helps to bring to light the history and connection of floodplain management for the United States, the town of Lyons, and the flood events that prompted change.



**Figure 1.** An overview of this investigation, detailing the paralleled reality of the history of flood events in Lyons, Colorado; the history of floodplain management in the United States; and the floodplain management of the town of Lyons.

## **Literature Review**

As our world changes, whether due to natural or anthropogenic sources, mass water events become more extreme, both in terms of damage and severity. Floodplain management has become an important part of life for dozens of communities around the United States and the world. In 2013, the Front Range of Colorado experienced floods that swept away memories, and shattered hundreds of lives. The study areas of historical hydrology and socio-hydrology aim to see how we, as a society, can better understand these human-water interactions and improve adaptability in our communities, by modifying past policies to current situations.

Historical hydrology, or the study of the interface between hydrology and history (Brazdil 2007), is mainly studied using scientific methods, and it often renders a history of hydrologic peaks for a certain area. Socio-hydrology is understanding the relationship between how water changes our communities and in turn how communities change the water landscape (Sivapalan 2012). Combined together, these areas of study help to identify how past incidences and policies have helped to shape the current political and hydrologic landscape.

Floods change not only the ecosystems that exist within the floodplain, but also the people that live in it as well. As seen in Lyons after the floods of 2013, people were evacuated from their homes, and some never returned (Illescas 2015). The monetary expense alone caused stress on families that limited how they were able spend in the future. And socially, people were called to the state of emergency to help their communities rebound. Eventually, everyone that was truly impacted by the floods, never truly returned to how they were pre-flood. There were psychological, social, and economic changes that have set up an event-effect relationship that is truly the foundation for this study. From this event-effect relationship, we would be able to determine how human behavior changes in terms of environmental extreme events, such as a

change in political oversight. But before this, a history of why rivers (or in Lyons, Colorado's case, St. Vrain Creek) were settled in the first place will lay a better understanding of why this human-water relationship exists.

Rivers and water sources have been vehicles for industrialization for decades. Waterways provide easy transportation for trading, often fertile farming soil, and a constant source of water. This is the main interaction between humans and water, demonstrating how we, as communities, use water to our benefit, and how that in turn creates a change in the water system. This is demonstrated best through Kristen Dow (2000).

Dow (2000) goes in depth on how communities and the environments around them create the urban landscape. Also, the article details how these relationships are founded through the use of three new social dimensions: land use, land management, and historical context. These new social dimensions combine together to help create the urban landscape of water.

What is important here is not only understanding how urban landscapes are created, but seeing the historical context as well. Dow (2000) expresses how looking into the past can help give clues to the future. That is often said about many things in life, but with water, the past is one of the true keys to understanding our water sources; in particular, how our management of our urban landscapes maintains healthy ecosystems around us. In terms of water, this demonstrates the true purpose of socio-hydrology. To use different methods, including looking into the past, to see how our interactions with water can be improved, to create healthy watersheds. With healthy watersheds, we could possibly see healthier populations and a stronger resiliency in the face of natural hazards. Overall, examining how people have reacted to past events (like the floods of 2013) can help improve future floodplain management.

How we have generated our urban landscape gives a base as to how we have contributed to the human-flood relationship. This connection is directly discussed in Baldassarre (2013), which describes that as people move into floodplains (eventually due to flood-preventing methods), flood occurrence goes down, however more catastrophic events occur. More importantly, this article describes how people perceive they have a lower risk due to the protection that is put in place after floods, such as levees and dams. While dams and levees reduce the chance for flooding, they also increase the chance for catastrophic floods, as they manipulate the natural flood system (demonstrating the direct relationship between society and hydrology). As we influence the hydrologic world, there is a pull from the other side of the relationship, that is crucial to consider before making future legislation.

This article links how people generating urban landscapes, described in Dow (2000), create a change in the flood patterns and occurrences of the floods, or some of the economic and social implications of this flood recovery relationship. In terms of socio-hydrology, this means that anthropogenic change does indeed give rise to a change in the flood pattern; Also, that if we have knowledge of our post-floods behaviors, we could change the infrastructure for the better. Our urban landscape, including anti-flood mitigation measures, has created an arena in which floods might occur less frequently, but catastrophic floods occur more often. The change that we have inflicted on our watersheds, in terms of industrial change, did indeed create a transformation in terms of our hydrologic system.

Implementing socio-hydrology in the context of Lyons is the next important step in this discussion. Sivapalan (2012) discusses the different aspects of socio-hydrology, but historical-socio-hydrology is where this discussion will mostly contribute. Historical-socio-hydrology looks at past water events and relationships more in depth to try and understand over a greater



period of time how water has shaped civilizations, and how we could use the data gathered to estimate patterns we could expect in the future. By going in depth into the history of flooding in the St. Vrain watershed, the progression of the town of Lyons' socio-hydrology and floodplain management can give key insights into possible future improvements.

Looking into the past to learn lessons for the future is a commonly used practice in many different fields. While this inquiry examines the St. Vrain watershed, looking at a different study that examines the same instance gives a clue as to how people might react in times of flood. In the case study, "*Socio-hydrology and the science and policy interface: a case study of the Saskatchewan River basin*," (Gober & Wheeler 2014), the Saskatchewan River basin (SRB) is given an in-depth look to tell the relationship between people and their watershed.

While this article does not necessarily give any recommendations or solutions to the problems that the SRB, and the town of Lyons for that matter, face; it does give an in-depth look at how the human-flood relationship plays out. Specifically, for the study of the town of Lyons, it suggests that as climate change, and resiliency to natural hazards, becomes more of a factor, the idea of water management will become more crucial. Not only will climate change play a role in water management and hazard resiliency, but water policy and land use will as well.

Both water policy and land use are integral to the idea of water management, because the floodplain is both enforced through water management and land use codes. Overall water management sets the margins for where people can build and how communities are protected through floodplain management. Communication between the chain of water management (FEMA, water managers, and water users), will become a crucial part of floodplain management in the future. Gober and Wheeler (2014) also suggests that it is important to treat this relationship as a whole unit and to respect its boundaries, and how it affects the population.

Discussed above is how our development actions have created an environmental response, but how humans respond and the psychological implications of this relationship, to these events is the next step in understanding post-flood policy behavior. In Seigrist and Gutscher (2008), it is discussed how flood mitigation does not simply come from technical analysis, but from displaying how emotional connection to floods creates better flood mitigation.

This study performed a survey in which they asked 99 people that were affected by a flood event in 2005, and 99 people that were not affected by the flood. Both groups were asked a series of questions related to the aftermath of the event, and how they felt their lives were impacted. Both groups were asked questions related to how they would use mitigation techniques to defend their houses from flooding in the future. The participants in this study represented several demographics of the community, and were not centered around one single group (Gutscher 2008).

The biggest aspect of this study was that the demographics polled were either directly impacted, (experienced an economic impact), or did not suffer in the same way. The results brought up familiar notions from Boulder County in 2013, in that most people that were not in the flood event seemingly could have underestimated the emotional toll of the flood (Seigrist & Gutscher 2008). Over all, this article delves into the gap in reactions that occurs with people that have been affected by an event and those that have not.

Understanding why people change their behavior is instrumental in creating effective policy. As discussed above, this often comes from experience of flooding and an emotional response to the event. Gruntfest (1986) establishes how the Big Thompson flood changed not only the lives of the people impacted by the flood, but national floodplain management as well.

Gruntfest (1986) sheds light on where floodplain management was ten years after the flood of 1976 that killed 146 people, and it offers a basis for original themes of floodplain management.

Through discussing the advancements of floodplain management and identifying gaps that still need work, Gruntfest (1986) was able to provide future policy recommendations. These recommendations pertain not only to the Big Thompson Canyon, but the nation as well. These recommendations include the transfer of flood hazard mitigation methods to other floodplains outside of Big Thompson Canyon, meaning, that every person who lives in a floodplain has the right to understand what living in a floodplain means and the responsibility to help prevent future damage. With the acknowledgment that these massive flood losses are not accidents, but can be reduced through human interference, gives rise to the importance of floodplain management.

Through previous discussions, it has been observed that people move into floodplains for several reasons, and policy is also changed because of previous flood experiences as well as other factors. Gruntfest (1986) also explains how it is crucial for the governing bodies that control these policies to be transparent in what their duties are, to help extinguish what the role of individuals and communities are in the face of flooding. Exposing the responsibilities that fall onto people who live in a floodplain, creates space for greater growth and understanding of what potentially could happen during a flood and after a flood event. This can help lead to greater community involvement and understanding, potentially reducing loss, both in terms of human lives and economically.

Gruntfest (1986) was one of the first publications to reflect on flood policy in a historical context. Using history to understand the present is a crucial element in preventing future disasters, and a central theme of this investigation. The Big Thompson flood presented a unique

opportunity to face our fears and become offensive instead of defensive. It also highlights how mass water movement can create policy change on a national scale.

How policies are implemented and changed over time in the face of floods in Lyons, Colorado, is best described in Albright and Crow (2015). This paper identifies how the different stakeholder groups present in a flood-prone community have differing beliefs on how they perceive flood risk. This paper identified the town of Lyons directly, and it points to an important viewpoint on the locally driven flood management described later in this investigation. Albright and Crow (2015) helps to drive home the point of how risk perception depends on several different inputs, including disaster experience, the individual experiencing the flood, and the social processes that surround the community. These are important because in order to perceive risk, people rely on past experiences as a way to understand and maybe justify their current beliefs in the face of the hazard. In terms of the town of Lyons, this indicates the direct relationship between this investigation and the community itself, as several of the residents have many mass water events to recall upon, to help them perceive future risk.

Considering that past experience is crucial to understanding future events is a single person's capability to relay that message to others. Albright and Crow (2015) further discuss how through individual motivation, community-wide legislation can be created. How a single idea can grow over time is crucial to the town of Lyons especially because of its size. Each individual can have a determining impact on the future they want for their community, and this includes how they build resiliency policy.

The conclusions of Albright and Crow (2015) indicate how Lyons is a community holding the reins behind their recovery, and are capable of achieving incredible flood resilience.

Understanding how the town of Lyons understands the true impacts of living in a floodplain, helps to direct the type of recovery and mitigation they plan to have.

## **Objectives**

The town of Lyons has always been located in a floodplain, a fact that is not going to change; But what has changed is the management policies that have been implemented to help protect people living in these areas. The objectives of this study are not only to fill the gap that surrounds the human-flood interaction, and contribute to historical and socio-hydrology, but also to the field of hazard prevention in the face of climate change. It is the hope of this study that when this discussion has concluded, floodplain management will become more understood as the town of Lyons' history of flooding will help to enlighten how floods shape communities.

Another objective of this study is to help engage in how policy is created, and how certain water events help to shape the political landscape. Furthermore, there will be an extension of this paper that lends potential policy recommendations for the town of Lyons, based on past flood events and floodplain management the town of Lyons has experienced.

## **Methods**

The methods used to identify the historical hydrology of the town of Lyons included evaluating United States Geological Survey (USGS) data to understand the peak hydrologic events, as well as the damage from these events. This gives an understanding of the how many times the town of Lyons has seen mass flooding, and what damage occurred because of the event.

From there, flood legislation and the history of the town of Lyons were investigated through researching several academic resources including the Colorado State University Water Resources Archive, Boulder Carnegie Library, and most importantly through the compilation of

flood legislation the town of Lyons has available through FEMA, Boulder County, and the town of Lyons, itself. Through analyzing different policies, for both the Town of Lyons, and floodplain management overall, trends in policy change could be identified and explored.

### **History of Flood Control in the United States**

Understanding where policies come from, as well as, the origin of floodplain management gives an idea of how long society has attempted to manipulate our surroundings, and how adaptability to flooding has evolved over time. For this investigation, this inspires one of the major themes of how money and the recurrence of floods are the real drivers in motivating floodplain policy. Also, this timeline demonstrates how, over time, floodplain management policies have gone from a local responsibility, to a federal responsibility, and it is now somewhere in between, commenting on the difficulties in creating comprehensive and integrated flood policy for communities.

There are many large river deltas in the United States, that are home to thousands of people, and represent an important trade function for several communities. When one of these deltas floods, it wreaks havoc and destroys livelihoods. The government of the United States has utilized several different methods to help curb this devastation caused by floods, and other natural disasters. While the Western United States, including the town of Lyons, Colorado, was still being developed, the Mississippi River Delta was a flurry of activity, and the main channel for the United States trade industry. Just like any other delta, the Mississippi River floods, however, not like any other delta at the time; people were dying, and infrastructure was crumbling.

### **1879 Mississippi River Commission**

On June 28, 1879, under the Secretary of War's control, Congress passed the *Mississippi River Commission*. This group was responsible for navigation and flood-control on the Mississippi River (USACE "Mississippi Commission"). The commission's responsibilities included making, "...surveys and investigations necessary to prepare plans to improve the river channel, protect the banks, improve navigation, prevent destructive floods, and promote commerce" (USACE "Mississippi Commission"). The Mississippi River Commission represented the first time the United States government was ready to make intended modifications to disturb the normal flood routine of rivers to protect people and infrastructure (USACE "Mississippi Commission").

The Commission's initial methods for flood control were mainly utilizing and planning a system of dikes and levees as well as; preventing riverbank erosion using retaining walls and other fortifications. Even with the creation of the Mississippi River Commission, there was still a massive amount of responsibility that landed on local participants and landowners to mitigate flood damage (USACE "Mississippi Commission"). This would lay the ground for the battle between local and federal government in terms of property and land use that persists in many ways today.

### **1886 River and Harbor Act**

There were other battles in the stride for flood control besides citizen concerns. As with other technological advances, there were several roadblocks on the way to reducing risks to living in a floodplain. *The River and Harbor Act of 1886* (USACE "Headquarters") restricted the way the Commission was receiving funds for projects, and rejected fortification as a reputable flood control measure even though it had shown promise (USACE "Headquarters"). This demonstrated the disconnect between our knowledge of floods, and the policies we created as an

engineering method that was thought to be crucial was taken off of the list of viable options (USACE “Headquarters”).

The restricting of flood control policy continued into the years 1881 through 1892, as there was strict restriction on the Commission’s funds. During this 11-year period, the Commission was not allowed to fix levees on private property. This meant that if levees were broken, they had to be on public land or for navigation, in order for the Commission to repair them. Coincidentally, fixing the levees was only in the interest of assisting navigation at this point. Overflow prevention was a welcomed byproduct of such repairs. However, in 1892, when these financial limitations were lifted, the Commission had decided that, in general, overall a levee system would be enough to protect the Mississippi River from overflow, creating the “levees-only” system (USACE “Headquarters”).

#### **1917 Flood Control Act**

Flooding on the Mississippi River in 1912, 1913, and 1917 led to the first flood control act. *The Flood Control Act of 1917*, gave more economic capability to the Mississippi River Commission. The Act ensured watershed studies were completed and utilized before construction of new flood control methods started. What makes this significant, is that it was one of the first times that nation wide flood control was considered, as projects were expanded to the Sacramento River Basin as well (USACE “Headquarters”).

#### **1928 Flood Control Act**

After the Mississippi River flooded in 1927, killing 500 people, new legislation was needed to help ensure the safety of communities. *The Flood Control Act of 1928*, created an opportunity for a more comprehensive strategy for flood control, and the Act allotted even more



funds to the cause, allowing for control of the Mississippi River Commissions projects to be given to the Army Corps of Engineers for completion (US Con 1928).

### **1936 Flood Control Act**

Even with these newly updated flood control policies, deaths were still occurring in other areas of the country, due to flooding. The next installment of the plan was in the *Flood Control Act of 1936* (USACE “Headquarters”). In this piece of legislation, the United States government admitted it was federally responsible for flood control, meaning the entire country had the right to protect themselves from flooding, taking the idea of mitigating floods from a private responsibility to a federal one.

Even though at this time, reservoirs were not necessarily considered a viable way to prevent flood loss, the *Flood Control Act of 1936* gave the Army Corps of Engineers funding and employment to build reservoirs around the country (USACE “Headquarters”). With hydropower being a major priority, this Flood Control Act also made sure that projects from 1936 and forward would make a genuine profit (USACE “Headquarters”).

### **1944 Flood Control Act**

*The Flood Control Act of 1944* (USACE “Headquarters”), enabled the Department of the Interior to sell the hydropower that was being created from the flood control dams, and instituted the first multipurpose projects. These new dams were instituted for, “flood control, irrigation, navigation, water supply, hydropower, and recreation” (USACE “Headquarters”). Tying all of these strategies together makes for a more comprehensive strategy to help control flood mitigation throughout the country.

### **Development of FEMA**

While this was an important step in comprehensive floodplain management, there was

still a lot of room for growth. In 1965, another *Flood Control Act* was passed, creating more access for the Army Corps of Engineers to implement their projects, including Lake Pontchartrain and other flood protection projects (USACE “Headquarters”). The next step was in 1968, when the *National Flood Insurance Act* made flood insurance available to homeowners (FEMA “About the Agency”). This is important because it created a mitigation pathway for individual homes to become more resilient to flooding.

The *National Flood Insurance Act* was a crucial first step in taking flood prevention from a federal level back down to a community level, and demonstrated how important flood resiliency had become to everyone in the county. By 1973, the *Flood Disaster Protection Act* made it mandatory for homeowners to buy flood insurance if they lived in Special Flood Hazard Areas (FEMA “About the Agency”).

Through this fragmentary approach, it was still obvious that there were holes in the flood and hazard mitigation system. In order to unite the agencies, President Jimmy Carter instituted, the Federal Emergency Management Agency (FEMA) on April 1, 1979. It was created to aid people in times of natural hazard crisis, including flood recovery. FEMA is an important voice in this discussion, as the town of Lyons has relied on FEMA several times through the National Flood Insurance Program. The town of Lyons also relies on FEMA to help the town recover both physically and economically from flood events.

The history of floodplain management engages how long it takes for management to be implemented, and how it takes major events to present viable management options. In this conversation, the idea of comprehensive floodplain management was presented as a centralizing theme. This is still current within the town of Lyons today, as people reach for ultimate resiliency.

## **The Big Thompson Flood**

Looking back to the past, in terms of national floodplain management, gives a bigger backdrop as to the ways the town of Lyons has had to adapt to how the nation deals with floodplain management. But bringing nation-wide policies to the foreground of Lyons is an important step. The Big Thompson flood changed the landscape as to how people living in floodplains needs to be addressed, as it was one of the most impacting floods in the history of the United States. By zoning in on a major event in Colorado, the floods in the town of Lyons can be given more background and helps to launch themes of this investigation.

The Big Thompson flood established how important land use in floodplains is and the town of Lyons is not any different. On July 31, 1976 143 people were killed as a flash flood erupted through the Big Thompson Canyon (Gruntfest 1986). As floodplain management had not yet been considered for the state of Colorado, this event highlighted how people needed to adapt to where they live, and how flooding was a real and present danger to the community. In terms of Lyons, currently there is a buyout program, which has so far bought 16 properties (Lyons 2016), but who knows if this piecemeal approach will remain important to the people of Lyons moving forward, especially as affordable housing is a major issue. One of this biggest issues with land use development and floodplains, as seen over time, is that our memories are short. By that, it can be said that as the event becomes a memory people are not as motivated to create change, and as a result people's priorities change.

Through looking at how our nation has developed floodplain management policies, and looking at events that have made Colorado an especially important place to study, many essential themes are stitched together for this investigation. In some ways, it seems we have learned so much from the many floods that have devastated our nation, including the Big Thompson Flood;

however, we are always learning. The town of Lyons now has well defined floodplain management strategies, but it was not always that way.

### **Initial Floodplain Management in Lyons**

While understanding the historical implications of national floodplain management is crucial to understanding how people perceive flooding, in terms of Lyons, there was no known floodplain management leading up to 1972 (FEMA 1995). However, with the development of FEMA, and major flood events like the Big Thompson Flood, the idea of floodplain management became an important aspect of planning for the town of Lyons. In 1976, Colorado became an important stomping ground for floodplain management, when the Big Thompson Flood gave new heights to the horrible ways flooding can corrupt communities. Initial flood insurance studies and the June 1972 and September 1972 St. Vrain studies performed by the Army Corps of Engineers (USACE) show that there was great interest in the idea of floodplain management for this area, but no legislation or studies were published until 1980 (FEMA 1980).

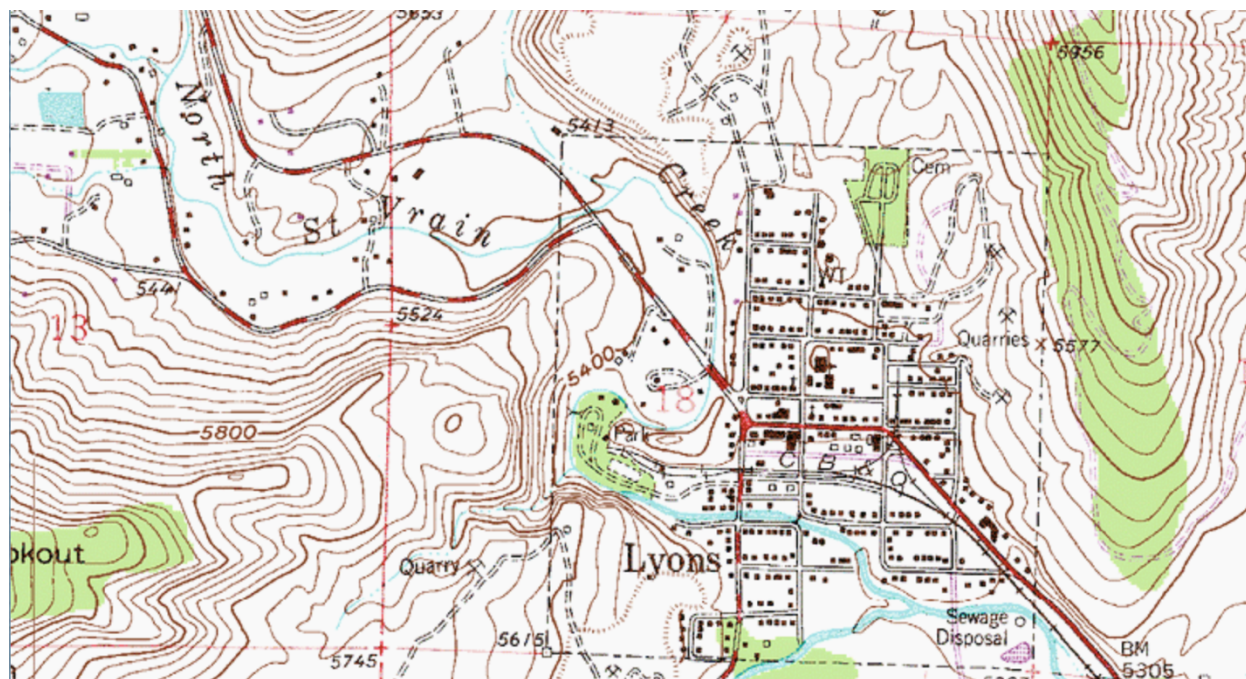
### **History of Lyons**

By understanding how floodplain management has evolved overtime, the backlight for how Lyons fits into the overall puzzle can be better understood. The town of Lyons, Colorado lies in the shadow of Longs Peak, and is settled next to the confluence of North St. Vrain Creek and South St. Vrain Creek. During the early 1800s several Native American tribes settled in and around the confluence, including the Ute and Arapahoe Tribes. White settlers then moved into the area upon hearing of the gold rush, leading to a boundary survey from 1870-1874 (USGS 997). In 1880, Edward. S. and Adeline Lyons decided to settle the town of Lyons for its substantial quarry opportunities; and in 1891, Lyons became an incorporated town in Boulder County (USGS 997). From here, the infamous Lyons sandstone mine was created and exported

thousands of pounds of sandstone all around Colorado. Today, Lyons is home to 2,033 people, and still remains at the confluence of the North and South St. Vrain Creek (Lyons “About the”).

### Geographic Landscape

How the town of Lyons is set up, both geographically and in terms of infrastructure sets the stage for how floods can wreck such havoc on the community. St. Vrain Creek finds its headwaters in the Indian Peaks Wilderness and Rocky Mountain National Park, and it drains 219 square miles into the town of Lyons (Lyons 2010). The town of Lyons sits at the mouth of a canyon, and can be classified as a semiarid region. Being in a semiarid region (Boulder County, 1998, p.4) means that there is little vegetation, and the soil can be easily moved through flooding. Demonstrated in figure 2, the steep sandstone cliff sides that surround the town of Lyons make storm water come down the valley much quicker, and make flash flooding more common and intense (FEMA 1995).



**Figure 2.** An overview of the physical geography of the town of Lyons, highlighting the steep topography that leads to intense flash flooding for the community (topoquest.com).

The infrastructure of the town also makes it much more susceptible to floods. In 1995, many of the bridges were still built across channel restrictions, making them more vulnerable to increased hydraulic pressure and also trapping debris, causing damming and further restriction of the water volume (FEMA 1995). Promoted by flooding, erosion constantly changes the landscape and removes stability (FEMA 1995).

#### **Causes of Flooding for the town of Lyons**

The causes of the floods in this region vary between heavy rainfall, snowmelt, and cloudbursts. Many of the floods occur when fronts stall over the St. Vrain Valley and cause heavy rainfall for multiple days, as was the cause of the 2013 floods. These events can happen at any time of the year, but mainly in the late stages of the summer, typically May through September (Colorado Fishing Network 2016). Snowmelt is also another important indication of flooding, as the snow is accumulates in the mountains, west of the town of Lyons, and then comes down through channels during the runoff season, usually May through June (Colorado Fishing Network 2016).

Cloudbursts are an important and usually unknown cause of flooding in the town of Lyons. Many of the major storms that have impacted Lyons have been caused by this unique weather phenomenon. A cloudburst can be defined as “a torrential downpour of rain, which by its spottiness and relatively high intensity, suggests the bursting and discharge of a whole cloud at once” (Woolley, ii, 1946). Several of the storms throughout the town’s history have been caused by cloudburst events, and it continues to be an important meteorological input to the hazard presence for the town of Lyons today.

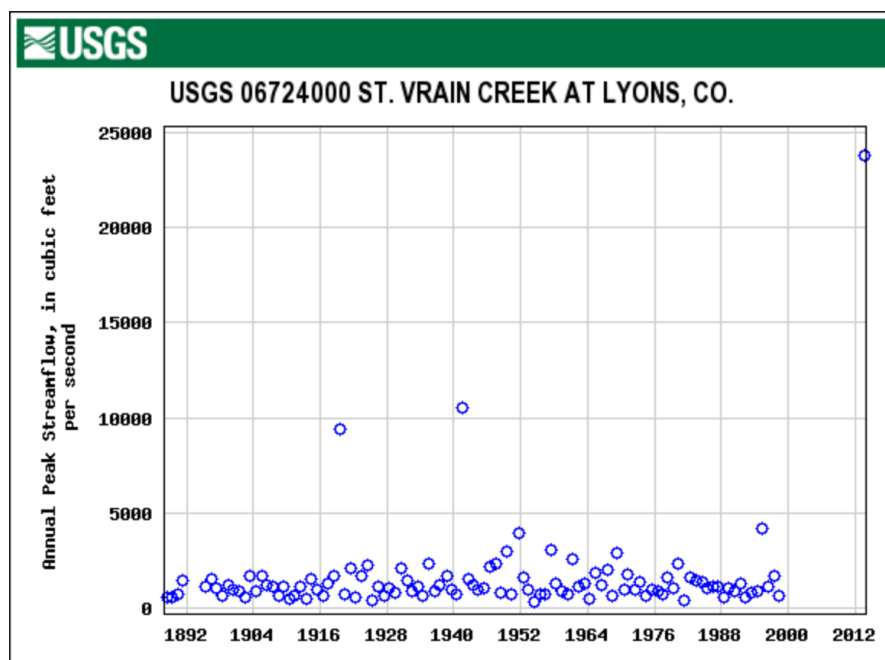
An important aspect of the geographic landscape includes understanding the streamflow data from the USGS streamflow gage. This gage provides information on how many cubic feet

per second (cfs) are travelling through the St. Vrain Creek at any given time. This is important in understanding the history of flooding in Lyons as the differing peaks have produced distinctive results in certain areas of the town. Also, looking at the different peaks that floods have had, gives a clue as to the extent of the floodplain. Specifically, the stream gage for the town of Lyons is located “.4 miles downstream from the confluence of the North and South Saint Vrain” (FEMA, 1995, p. 32).

#### **Streamflow data**

Streamflow is an important hydrologic tool utilized by FEMA to help secure a history of flooding for communities. Flood Insurance Rate Maps bring to light how the peak floods of 1919, 1941, 1951, and 2013 have produced the largest peak discharges in the current history of the town of Lyons. These discharges are as follows, in Figure 3. For the July 30, 1919, flood the peak discharge was 9,400 cfs. For the June 22, 1941, flood the peak discharge was 10,500 cfs. The August 3, 1951, flood event produced a peak discharge of 3,920 cfs (FEMA, 1995, p. 32). And finally, the September 9, 2013, flood produced a devastating peak discharge of 24,700 cfs (Yochum 2015). These are all important values in helping to delineate how floodplain management can be most effective and efficient, as these peak values give planners and contractors a sense of how much water could inundate the area, and what neighborhoods need to be floodproofed.





**Figure 3.** Stream flow data for the town of Lyons, indicating trends in the height of historic floods. Most notably the 1919, 1941, 1951, 1994, and 2013 floods (USGS).

## History of Flooding in Lyons

The history of flooding in Lyons is crucial to understanding how flood policy has changed (USGS 997). The first recorded flood (caused by heavy precipitation) in Lyons was in June of 1864. While this flood may not have a recorded peak flow, according to the USGS, the flood crippled much of the entire St. Vrain Valley, indicating that flooding has inundated the valley even before it was settled (USGS 997). Then again, in May 1876, heavy rain from a storm caused St. Vrain Creek and Lefthand Creek to merge and created a flood that, "...spread over the bottoms from bluff to bluff for 2 days" (USGS, 997, p. 38). On May 31, 1894 was the next time that St. Vrain Creek topped its banks. The rain fell for multiple days, and dropped 8.54 inches of rain over Boulder County (UDFCD). This storm caused an estimated discharge of 8.13 feet, or 9,800 cfs, on the USGS gage, which means that the flood was at the same level as the train tracks. Most power lines and bridges were washed away from Boulder to Jamestown, destroying 20 homes and taking three lives. The St. Vrain Creek was reportedly 3 miles wide (Defnet 1994).



Cloudbursts caused 1.75 inches of rain and much of the flooding of July 30<sup>th</sup> through August 2<sup>nd</sup> of 1919. During this flood, the water main was destroyed in both the town of Lyons and the City of Longmont. Bridges and roads were totaled five miles up and down the canyon. The lowest elevations. “were flooded out and many abandoned their homes for higher ground and safety.” (Jacobs 2014) The end of the flood resulted in 2-3 feet of water, inundating the town and costing about \$40,000 in damage (UDFCD). On July 30<sup>th</sup> 1919, it was determined that the flooding had increased the original channel width by 8 feet, and washed away 300 yards of railroad track. The overall estimated peak discharge was 9,400 cfs, and was incredibly destructive to infrastructure (UDFCD).

June 2<sup>nd</sup> through June 7<sup>th</sup> 1921, was when the next flood occurred. This flood had a peak discharge of 2,020 cfs, and was the highest flood in 25 years. The precipitation recorded for this event totaled 5.87 inches. According to the Boulder Camera on June 7, 1921, “The Creek is carrying more water and is higher in this region than during the cloudburst at Lyons 2 years ago.” (USGS 997)

September 2<sup>nd</sup> through September 4<sup>th</sup> 1938, saw a flow of 1,650 cfs through the town of Lyons. The max precipitation here was 6 inches and resulted in six deaths. This peak discharge was mainly due to the fact that ordinarily dry tributaries were inundated with water. Another flood occurred in Lyons on June 22, 1941, causing thousands of dollars in damage, and killing one. The peak discharge of this flood was about 10,500 cfs (USGS Streamflow), with 1.04 inches of precipitation (USGS 997).

Bridges and irrigation structures were destroyed in June 1949, as over 6,700 cfs of water pumped through the town of Lyons. This flood was mainly caused by high rainfall and

snowmelt, leaving much of the town besieged with flood waters for most of the month (FEMA 1995).

Cloudbursts on August 2<sup>nd</sup> and 3<sup>rd</sup> of 1951, caused another flood for the St. Vrain Valley. This flood killed four people, and costs the town of Lyons \$35,000 in damages. There was reportedly a 6-foot wall of water that came down St. Vrain Creek, carrying debris that triggered the evacuation of over 700 people (UDFCD).

May 8<sup>th</sup> and 9<sup>th</sup>, 1957, saw between 3 and 5 inches of rain fall on St. Vrain Creek. On May 9<sup>th</sup>, there was a peak discharge determined in the town of Lyons of 3,060 cfs. This flood destroyed much of the agricultural infrastructure in the town of Lyons, including irrigation ditches, roads, and bridges. More than 10 years later in May of 1969, heavy rainfall and snowmelt left St. Vrain Creek swollen for most of the summer, most notably from May 7<sup>th</sup> and 8<sup>th</sup>, and June 15<sup>th</sup> through June 21<sup>st</sup>. The peak discharge for the flooding from May 7<sup>th</sup> through 8<sup>th</sup> was 2,900 cfs, leaving much of the town of Lyons' infrastructure damaged (FEMA 1995).

On August 10, 1994, 3 inches of rain fell on Lyons, in about 30 minutes, as a front hung over the valley. Accompanied by high winds, of up to 100 miles per hour, new infrastructure was destroyed and power was out for about three hours. While there were no injuries or deaths, this flood signaled one of the first times the town of Lyons had decided to make a significant change in terms of policy after a flood event had occurred (Defnet 1994).

September 9<sup>th</sup> through September 11<sup>th</sup> 2013, was possibly one of the most damaging floods in the history of Lyons. Mainly due to the increase in population and land use, the 17 inches of rain that fell on Boulder County over a period of three days destroyed much of the infrastructure and residence of the town of Lyons, and killing four people along the Front Range (Brennan 2013). Beginning on September 9<sup>th</sup> and ending on September 11<sup>th</sup> the St. Vrain was

recorded at 10 times the normal flow, at a peak of 27,400 cfs (Yochum 2015). Even after the rain had ended and the flashfloods had rescinded, the town was left cut off from surrounding populations, and people were evacuated by helicopter on September 14. The town's power supply was down and the water main was destroyed (Lyons 2013). The destruction was so comprehensive that people were not allowed to return until six weeks after the flood waters had settled (Lyons 2013). The flood destroyed and damaged 168 homes and 43 mobile homes (Lyons, 2013, p.51) in Lyons, mainly along the St. Vrain Corridor and in the Confluence neighborhood. During this mass water event, several streets were damaged, totaling over a mile of infrastructure destruction (Lyons 2013). Numerous bridges were left inoperable, and possibly most critically the million-gallon water storage tank was disconnected from the main water line, as well as, the wastewater treatment plant lines were broken, signaling the full-scale destruction the town of Lyons had ever seen from flooding (Lyons 2013).

From the time Lyons was settled in the mid 1800s to three years ago in 2013, nearly 13 major flood events have impacted the town of Lyons, and some of the evidence of these floods can be seen in Figure 4. This is the basis for why floodplain management is so crucial to this 'town next to the river,' and it is the basic reason for this investigation. By looking through the different historical floods, the policies that were devised because of them, will lead to a greater understanding of the extent to which flooding has disrupted the town of Lyons, and in what ways growth can be made.



Figure 4. On the left a picture from the flooding in 1969 (FIS 1980). On the right, flooding from the flood of 2013 (voa 2013), both displaying destructive qualities these flood events have on the infrastructure of the town.

### **History of Floodplain Management in Lyons**

Evaluating the history of floodplain management in Lyons gives a clue as to how the town has formed resiliency to flooding. As discussed above, even though nearly 100 years of flooding was recorded before 1980, there was no definite management practices; people simply rebuilt, without necessarily acknowledging that a flood event might happen again. Below is the discussion of the evolution of floodplain management in Lyons, and how each piece of legislation changed how the town of Lyons acted, and whether the legislation was effective.

#### **1973 Flood Insurance Rate Maps**

The town of Lyons was initially evaluated through the National Flood Insurance Program in 1973. FEMA implemented flood maps for the area that were intended to help determine flood insurance rates, but these maps also are a strong contributor to how the town of Lyons has evolved over time.

As floods move through the town of Lyons, these flood maps are updated in response to what areas were most badly damaged. As demonstrated in Figure 5, the flood insurance maps for the years 1973 and 1996 show a vast difference in the designation of the floodplain. From the initial flood map of 1973 (which is only for the central part of town) to the Flood Insurance Rate

Map of 1996 (which goes through the entire town of Lyons). The difference between these two maps describes how over time, there have been dramatic differences in the areas that have been considered to be a part of the 100-year floodplain standard.



A.



B.

**Figure 5.** Figure A represents the 1973 Special Hazard Identification map (FEMA 1973) extending only through the town limits. Figure B is the FIS from 1996, delving into the full extent of the town of Lyons (FEMA 1995).

The maps detail how the floodplain has changed, and which areas were moved in and out of the floodplain. A house that is on the banks of the St. Vrain Creek now may not have been put in the initial floodplain study, and are now inundated with water when a flood hits. My discussion with Joe Kubala highlighted the different lots that were considered to be inside the floodplain somehow were not involved in the 2013 floods, and yet houses that were not within a Special Hazard Flood area were devastated. A house that is on the banks of the Saint Vrain Creek now may not have been put in the initial floodplain study, and are now inundated with water when a flood hits. My interview with Joe Kubala emphasized the different lots that were considered to be inside the floodplain somehow were not involved in the 2013 floods, and yet houses that were not within a Special Hazard Flood area were devastated. These maps help to

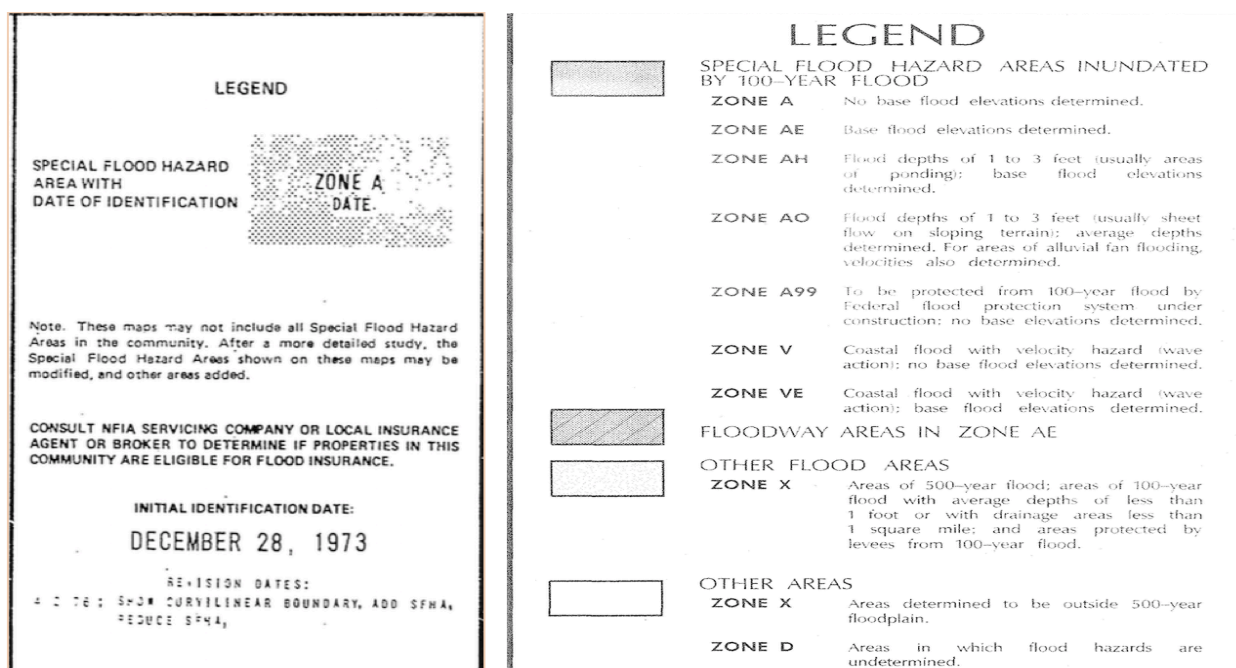
detail how, over time, the floodplain changes, and implements measures that the local government believe are necessary to keep people safe, as well as to save money.

### **1980 Flood Insurance Study**

While flood insurance rate maps were created for the town of Lyons in 1973, the first *Flood Insurance Study* (FIS) for the town of Lyons was performed in 1980. According to the FIS, the objective of this study was to fully integrate the town of Lyons into the Federal Insurance Administration programs (FEMA, 1980, p. 1), and to identify the existence of flood hazards from St. Vrain Creek in the town of Lyons. It is significant to note here that leading up to this study the channels for St. Vrain Creek were essentially untouched and in its natural state (FEMA, 1980, p.5).

Through a hydrologic study of Lyons and national FEMA guidelines, the largest aspect of this study is that the floodplain boundary designated for the town of Lyons was the 100-year floodplain. With this designation, different sections were created to help establish zones to give better understanding of where in the floodplain people could build in, and where in the floodplain would receive the most damage during a 100 or 500-year flood event (FEMA 1980). Zone A5 and A7 are understood as being in the Special Flood Hazard Areas, or would be completely inundated by a 100-year flood event. Zone B can be described as the fringe areas between the Special Flood Hazard zones and the boundaries for the 500-year floodplain, and Zone C is considered areas where minimal flooding would occur, demonstrated in Figure 6. While the maps, discussed above show true change in the 23 years between updates, the keys show vast improvements in how we saw floodplains as well (FEMA 1980).





**Figure 6.** On the left, the 1973 flood insurance map legend (FEMA 1973), noting especially how only Zone A is outlined. In the 1996 flood insurance map legend (FEMA 1995), there is a great more detail, and demonstrates the advancement in our knowledge of floodplains.

This initial study was groundbreaking as it gave an accurate and in depth look at the challenges that the town of Lyons faced as the population continued to expand while living in a floodplain. It also helped to establish how the town of Lyons would need to have strict land use guidelines in order to help keep the community's safe. However, as FEMA and the town of Lyons were still learning from flooding, this initial FIS existed to only create guidelines without any definite results.

### 1984 Boulder County Storm Drainage Manual

The *1984 Boulder County Storm Drainage Criteria Manual* communicated ways in which storm drainage could be handled in a more appropriate and efficient manner. In the town of Lyons, this opened up the possibility of county funding, and one of the first times the town of Lyons was pursuing its own floodplain management possibilities. This manual brought together management issues, as well as, technical hydrology issues. Originally, based off of an



Environmental Protection Agency study from 1975 for storm water management, this manual was one of the first strikes at a cooperative look at floods and the communities they impact.

One of the most important goals of this document was to unify the entire county of Boulder under guidelines that were important to the entire county, and the individual communities within the county. This can be seen in the way this report was prepared (Boulder County, 1984, p. i). One of the first steps was to review local guidelines and county planning and zoning codes to create specified manuals for each outlet of Boulder County, again pointing to a cooperative approach to storm management. At the time this was written, flood insurance was still a great unknown, and even today still lacks ability to take hold in overall floodplain planning and management. This manual hoped to simplify these at the time, state-of-the-art, management techniques. Beyond this, the general resolution of this manual was to elicit widespread understanding of the methods that cause floods, and how, in 1985, Boulder County was ready to battle them.

To Lyons, this manual was only of small significance. It does acknowledge that there was a regional analysis performed by the EPA, and through previous Boulder County studies, indicating some basic motivation; but this manual does not give direct regulation recommendations for the town of Lyons, and future hazard mitigation strategies. One thing it did very well was to identify the many different legislative plans that went into this study, building upon the theme of creating current policies based on former policies. Foremost, the notion that the town of Lyons has its own right to choose its floodplain management tactics was fundamental because, while the town of Lyons resides within Boulder County, it is still its own entity, and should have the responsibility to create its own future for floodplain management (Boulder County 1984).

Throughout this investigation, every piece of legislation that was consulted builds and refers to previous documents, and also helped lay groundwork for the next installments. In 1994, following the floods on August 10<sup>th</sup>, Lyons created its first *Flood Hazard Mitigation Plan*. Approved by then Governor, Roy Romer, and through the Colorado Office of Emergency Management, this plan helped to identify the fact that infrastructure needed to change in order to reduce the cost of flooding (Defnet 1994).

#### **1994 Flood Mitigation Plan**

The plan set out to identify how long the town of Lyons has been situated within the floodplain, and how mitigation plans have not really been implemented in the past. Similar to this thesis, the *1994 Flood Mitigation Plan* aims to go back through, not only the flood in August of 1994, but also to go back through the history of flooding in the town of Lyons as well. One of the largest acknowledgments of this plan is the continued acceptance that most of the residents reside in the 100-year floodplain (Defnet 1994).

The town of Lyons' drainage system, which flooded during the August 1994 flood, was a large indication as to why a flood plan was needed. The original purpose of "the ditch" was to guide stormwater from the South St. Vrain through the residential part of town, and eventually into the North St. Vrain. However, as the years between major flooding is not consistent and the last major flood was 25 years earlier (in 1969) the ditch began to become covered for other uses (Defnet 1994), including landscaping and road infrastructure practices; as well as, the ditch falling into general disrepair. This contributed to this specific flood strictly because of the low-volume capability of the ditch, and how it could not hold the peak flood that rushed through it (Defnet 1994).

Another important issue presented here that is a true theme of floodplain management, and seen in the history of floodplain management, is the notion of private versus public land. In this plan, this issue is presented as the fact that parts of this ditch (the drainage system for the town of Lyons) was owned by many different private owners and the town of Lyons. This means that the upkeep was in the hands of these different property owners and was not held to any specific standard. This plan also attributes upstream buildup to a constant source of erosion. The roads that were built had, as a consequence, taken away the natural flood-reducing vegetation, and created impermeability, establishing an even more systemic reaction of erosion, progressing destruction of the town of Lyons due to excessive water (Defnet 1994). All of these acknowledgements of past failures in floodplain manage indicate how while plans were made nothing was really done to prevent future flooding.

The solutions found in this plan included a longer term forecasting of floods. It is important to recognize how the flood warning system for the Town of Lyons was through a generalized Boulder County Emergency Operation Center (EOC). This is the center that set up organization for the recovery of the Town of Lyons after this particular flood, was a part of the Multi-Agency Coordinating System (MACS). This is a crucial department that was set up to help make the recovery and warning system more cooperative, trying to combine representatives from the state, local, private, and public systems. These are the meetings that helped to create plans for hazards, including floods (Defnet 1994).

This office also put together the flood mitigation workshop that helped to promote floodproofing as a valuable means of floodplain management. The two types of literature the group handed out during these meetings was a *Home and Business Guide for the Mitigation of Flooded Basements* and *Tips for Hazard Mitigation Flood Damage Control* (Defnet, 1994, pg.

14). Beyond individual residential floodproofing, the main concept to be taken from this plan is the mitigation solutions for several different parts of Lyons. For the North-Central part of Lyons, the most damaged part of the town, the recommendations included adding a retention pond to catch the runoff waters from Steamboat Mountain. However, at the time this plan was made, the area that was scouted out for this project was owned by a private owner, illuminating the need for a cooperative, citizen-based flood mitigation approach (Defnet 1994).

Another area of town that was slotted for mitigation was below the Eastern Hogback on the Eastern side of the town. The mitigation plan here was decided to be too cost prohibitive and not fundamental for the town because of the underground pipes in the projected area. However, individuals in the area and around the town of Lyons were encouraged to floodproof their own homes, but there was not concrete funding for these projects at the time.

The conclusion of this plan was utilizing the National Civilian Community Corps work to help establish recovery. This means that all of the absorbed costs for site review and individual housing floodplain management would be absorbed by the Office of Emergency Management, engaging the need for federal government money (Defnet 1994).

This plan helped to recognize the holes in how mitigation has been molded throughout the years. The recommendations are a great start, but even in the year 1994, there is a glaring hole in how funding was secured for flood recovery, and even less foresight was given into how funding would be secured for future floodproofing. Generally, this plan made a lot of noise but did not give way to any sincere changes.

### **1995 Flood Insurance Study**

The *Flood Insurance Study* of 1995 was the updated study of the founding *1980 Flood Insurance Study*, also updated in 2002, and lastly in 2012. The 1995 study goes through the

hydraulic parameters of Boulder County and other incorporated areas, and most importantly, the most urgent flood problems for each area. The goal of this study is to help identify the differing levels of flood insurance for each area and how management practices could be improved and utilized to help better protect communities. An important note here is how this study aims to help create cooperative policy making. This is done through implementing policy from both the *National Flood Insurance Act of 1968* and the *Flood Disaster Protection Act of 1973* (FEMA, 1995, pg.1). This is crucial because it pinpoints how it takes several years of combined policy to create healthy floodplain management.

The study is split up into several different segments that go into independent updates of all cities, towns, and unincorporated areas of Boulder County. It also implicates and overviews the engineering methods that go into failed or successful floodplain management tactics, and from there, goes into how floodplain management is applied for each differing geographic area. Conclusively, the study ends with insurance recommendations (FEMA 1995).

The main streams that were studied using intricate hydraulic methods include the St. Vrain Creek, St. Vrain Secondary Channel, St. Vrain Creek running through Lyons, North, Middle, and South St. Vrain. This is important because it outlines every channel running through the town of Lyons, or the channels that disrupt daily activity during a flood. The principal flood problems addressed in this study was identified as the fact that the town of Lyons is in a natural bowl and the fact that the town of Lyons lies at the base of the convergence of the North and South St. Vrain streams (FEMA 1995).

The dams surrounding the town of Lyons are an often overlooked aspect of the flood-hazard portfolio. The 1995 report details how the Button Rock Dam and Longmont Dam were not constructed for stormwater retention, and instead, offered some remedial defenses. Other

than these two dams, previous floodplain management tactics included the channelization of several roads in Lyons and some small levees used for the defense of the trailer park (FEMA 1995). What is interesting to note here, is that most of these strategies are for the protection of Longmont, not necessarily for the defense of the town of Lyons in the eyes of FEMA. For the town of Lyons, FEMA suggests there are only nonstructural flood plain management utilized, and that building codes were enough to protect the citizens (FEMA 1995).

Most importantly are the updates of the floodway and floodplain boundaries. Through the *1995 Flood Insurance Study* housing and structures that raise the base elevation by more than one foot are now defined as being in the floodway (FEMA, 1995, pg. 53). This means any development that would increase the flood velocity, heights, and ultimately the damage of the flood, would now be considered to be in the floodway. Beyond this, the floodway fringe is explained as being the area overlapping the floodway and the 1 percent chance annual floodplain (FEMA, 1995, 54).

This flood insurance study is an important update from the original *1980 Flood Insurance Study*, however, overall it did not give any important insights into how the town of Lyons could be better prepared for massive flood events, but did help to clarify important floodplain boundaries.

#### **1998 Town of Lyons Drainage Master Plan**

The *1998 Town of Lyons Drainage Master Plan* was commissioned to help identify the problems within the town of Lyons' infrastructure and help to upgrade the system to defend against flooding in a more pragmatic way. One of the greatest problems identified in this plan was the notion that much of the stormwater management infrastructure was outdated and was not able to withstand the flow of future floods, previously identified in the *1994 Flood Hazard*

*Mitigation Plan.* Another input causing stress on the storm water system was the increasing population of the town. With more people comes more development and increased chance of destruction.

There were several goals identified in this master plan. To begin, there was an overlying goal of the town of Lyons establishing responsibility for their own stormwater plan. Floodplain management has been left up to developers to follow FEMA regulations, the town of Lyons municipal building codes, and the Colorado Department of Transportation guidelines, without the necessary oversight of the town of Lyons, itself. This plan hoped to establish "...ownership, maintenance, and funding on drainage projects" (Drainage Master, 1998, pg. 1). Specifically, this plan aimed to be transparent on how the town of Lyons' budget would be delegated to include floodplain management. On this note, another important goal of this plan was to produce more transparency on how funding would be established, including finding new sources of funding.

Stormwater management often straddles the line between being cost effective as major floods do not often occur more than one year in a row. However, other public works such as roads and water treatment are used every day and often take priority in funding. This plan hoped to help carve out more pathways for funding to help advance the floodplain management in the town. Within the designation of the floodplain, there are also proven problems with how the system has been able to take control of minor drainage problems that contribute to often larger major drainage problems; that is, property owners only maintain their stormwater systems without greater concern for the repercussions to the greater area. Finally, the problems identified for further exploration was how further development will implement new, more identifiable, stormwater solutions (Drainage Master 1998).

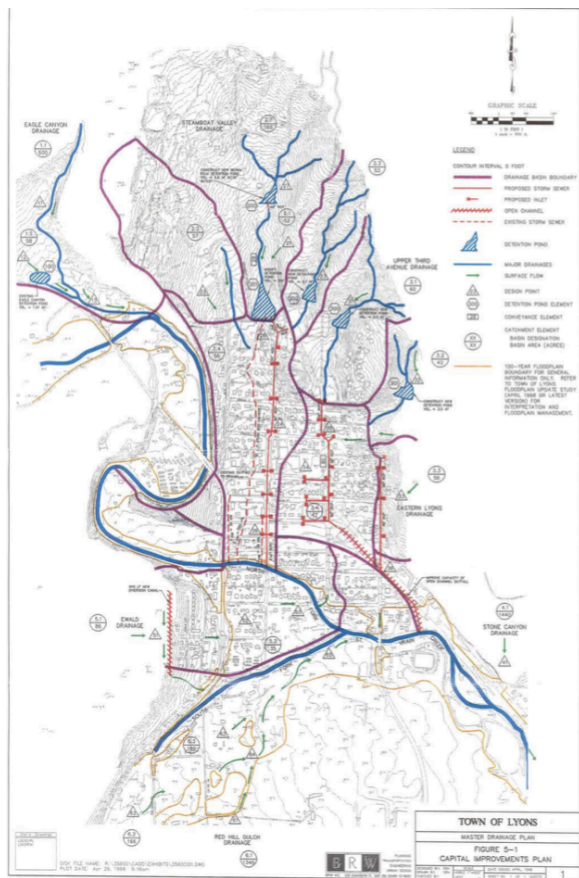
The largest theme of this plan was to incorporate already existing infrastructure in order to save money while updating the stormwater drainage system. Ultimately, creating a long-term plan as the semi-permanent versions of the past was not sufficient. The concept of creating open space and recreation within the storm drainage system, was also presented for the town of Lyons in this plan (Drainage Master 1998).

The flood this plan focuses on the April 10, 1994, cloudburst event. It hones in on this occurrence because it highlights how insufficient the drainage system was. An important note here is that many of the water pipes in the town of Lyons were still wood at this point (Joe Kubala), and the entire system lacked upgrading. This plan exemplified the outdated quality of the system as “the primary drainage system, comprised of a historic open-channel ditch and closed culvert built of sandstone, was overwhelmed and backed up water into businesses and residences” (Drainage Master, 1998, pg.13).

The theme seen throughout the plans so far is that floodplain management is often a byproduct of another more important form of management. Button Rock and Longmont Dams hold back a small amount of stormwater, staving off some damage that could have occurred, however, stormwater detention was not the true purpose of the dams. Then again, with the drainage system during the August 1994 flood, the old drainage system could handle minor events but caused urban flooding when pressed too much (Drainage Master 1998).

The recommendations made for the town of Lyons from this plan was to gain control of what is developed in the floodplain (as demonstrated in Figure 7).





**Figure 7.** Detailed overview of the plans for the *1998 Town of Lyons Drainage Master Plan* for the Town of Lyons (Drainage Master 1998).

Beyond federal FEMA regulations, the town of Lyons should also have its own management regulations creating transparency in funding and building permits to help streamline and thoroughly look into the building process including Elevation Certificates, Letter of Map Revisions, and Letter of Map Amendments (Drainage Master 1998). Another important part of the town of Lyons' government taking control of floodplain management was making sure that all of its residents were aware of the actual and apparent risks of living in a floodplain; this includes flood insurance notifications. While taking control of the town's floodplain management, this plan suggests the cooperation and modification with Boulder County and the Colorado Water Conservation Board to help accept FEMA regulations, thus creating a community of support for the St. Vrain Creek floodplain (Drainage Master 1998).

## **2008 Boulder County Multi-Hazard Mitigation Plan**

The *2008 Boulder County Multi-Hazard Mitigation Plan* was a complex portfolio of the different hazards that could affect Boulder County. In terms of the entire county, flood was listed as one of the top priorities in terms of mitigation, and was one of the most significant hazards to plan for. In other words, “10-50” (Boulder County, 2008, p. 4.34) percent of the county lies within a floodplain or flood-risk zone. The plan consists of identifying the hazard, planning a mitigation strategy, and then implementing the mitigation strategies.

Floods in Boulder County in 2008 were listed as a significant hazard based on the geographical extent of the area; and this is especially true for the town of Lyons. In terms of the planning process, Boulder County consulted the town of Lyons’ Commissioners Office to implement policy. This plan outlines how 3 inches of rain is how much it takes for a flash flood to inundate the 100-year floodplain (Boulder County 2008).

While this paper focuses on floodplain management from storm events, it is important to recognize that other types of flooding could occur in Lyons because, as discussed above, many of the multipurpose infrastructure that are implemented to help with water storage or irrigation delivery can also fail, causing floods. Dam failures and irrigation overflow are mentioned in this plan, but mainly just as a consideration (Boulder County 2008).

The different types of buildings identified for discussion in this plan include residential, commercial, agricultural, and other buildings that did not fit into the other four categories. Within this model of vulnerability, infrastructure that was built above the base flood elevation or other floodplain development ordinances was not included in the count of housing that was considered to be in danger. In other words, this plan is mainly modeled for infrastructure that

was built floodproofing was considered a viable and important measure of flood protection (Boulder County 2008).

Being aware of FEMA's role in flood resiliency and floodplain management is crucial to understanding how the federal government has helped shape the town of Lyons. In order to be considered a serious recover case after a flood, and receive federal assistance, FEMA has identified that a total loss value of greater than 10 percent of the town needs to occur, determined evaluating land parcel values and possible loss values. (Boulder County, 2008, 4.121). The total number of land parcels that exist in the 100-year flood zone in Lyons was 123 parcels of land, with a value totaling \$29,442,750. These parcels had a loss estimate of \$5,888,550, or a possible loss ratio of 3.3 percent of the total buildings in Lyons. In the 500-year floodplain there are an additional 32 parcels of land included in the assessment, adding a loss estimate of \$2,041,710, or subsequent 1.1 percent to the overall possible loss ratio to the town of Lyons. In total, this means that there were 155 total parcels of land in the 100-and 500-year floodplains, with a total loss estimate of \$7,930,260 and 4.4 percent loss ratio (Boulder County 2008, Table 4.28).

Another important value is the amount of people invested in the National Flood Insurance Program (Boulder County 2008). For Lyons, in 2008, there were 72 insurance policies involved in the town Lyons, mainly in the residential sector. These values are important because they give a value as to how much could be damaged by flooding. Also, all of the historical and critical facilities in the Town of Lyons have a number one hazard of some type of flooding, meaning that every person in the town is susceptible to some type of destruction. Also of importance here is gauging how many parcels could be bought in a buyout program, and actually how FEMA sees the town of Lyons, in terms of economic value (Boulder County 2008).

Within this county plan is an in-depth analysis of the town of Lyons, itself. Along with the above values, there are several different overviews within the plan. This plan was a combination of the *1998 Lyons Comprehensive Plan*, the *Storm Drainage Master Plan of 1998*, and the *Lyons Flood Hazard Mitigation Plan of 1994* (Boulder County 2008). This is important because it points to the fact that policy is a continual buildup of past policies and town experiences.

### **2010 Colorado Floodplain Damage Prevention Ordinances**

The *Colorado Floodplain Damage Prevention Ordinance* of 2010 was implemented by the Colorado Department of Natural Resources and the Colorado Water Conservation Board to help apply new ideas of floodplain management in order to create healthier and safer lives of those living in the danger zones. While this plan is not specifically tailored to Lyons, these ordinances give the overview of how Lyons was to develop in the future. This is especially important because Lyons needs help from every agency in order to recover from floods, and especially now, to create resiliency from floods, in other words, how the town of Lyons can prevent floods in order to produce resiliency (Colorado Department 2010).

Discussed above is how Lyons, through several plans, had hoped to create more space for responsibility in terms of its own floodplain management. What makes these statewide ordinances important for the town of Lyons is the specific and important delineation of the clear-cut duties of a floodplain administrator, include advising, implementing, and possibly more significantly enforcing floodplain management tactics (Colorado Department 2010).

A reoccurring theme of the town of Lyons' legislation is transparency through the entire process of floodplain management. Transparency is implemented through through these ordinances, by having the floodplain manager being available and clear on everything pertaining

to the floodplain administration, and how it might impact communities. This is important because not only are the records to be transparent but all decisions are to be open to questioning and public review. This gives a greater sense as a to a full-community operation that Lyons was hoping to make (Colorado Department 2010).

These ordinances mainly contributed to structures that were within the 100-year floodplain, or Special Flood Hazard Areas. There were several general standards that were put forth to be implemented in terms of building and floodplain standards. These include that all new construction and development must be constructed to prevent any further damage; that is, it must be built to withstand flooding in terms of “flotation, collapse, and lateral movement” (Colorado Department 2010). These ordinances establish floodproofing as communities are built to create safer housing and to reduce economic strain (Colorado Department 2010).

In terms of floodways, this plan is incredibly important. As defined above, “floodways are administrative limits and tools used to regulate existing and future floodplain development” (Colorado Department, 2010, p. 20). Defining floodways more clearly is crucial because it outlines how Colorado State handles floodplains and the stipulations the town of Lyons has to follow in order to be in compliance.

These ordinances were issued in hopes of creating a statewide system to help abate the effects of flooding. Since these statewide ordinances are often stricter than FEMA regulations, this document puts a tighter hold on the building requirements for the town of Lyons, which is already stuffed to the gills in terms of housing availability. While vague in specific recommendations for the town of Lyons, these ordinances do represent how the town of Lyons is held responsible for its floodplain management through identifying specific guidelines the town has to follow (Colorado Department 2010).

## 2010 Town of Lyons Comprehensive Plan

An extension of the 2008 Boulder Hazard Mitigation Plan is the *2010 Town of Lyons Comprehensive Plan*. This was created to help further the goals of the town and to help outline future ideas for the direction of the town. Through the use of goals and implementation strategies, the plan illuminates the economic, populace, and environmental goals for the community, outline in Figure 8. In terms of flooding, this is important in outlining future land use regulations to keep Lyons safe for years to come, demonstrated in the Town Services Objective 1.2, to “Keep Lyons safe and secure” (Town of Lyons 2010).



**Figure 8.** The branches of the plan, extending to the different branches of the plan, and the priorities and direction of funding. (Town of Lyons 2010)

While essential for the direction of the town, this plan was essentially more for the general direction of the town of Lyons and seemed very vague in the ordinances it suggested for floodplain mitigation and management. With the magnitude and length of the plan, it was a missed opportunity to make true advances in terms of floodplain management (Town of Lyons 2010).

Most of the legislation above was implemented without being tested by a flood, or simply waiting to see how the objectives mentioned in plans before the 2010 Comprehensive Plan would hold up. However, in September of 2013, all of the floodplain management history of Lyons was put to the test, and washed away.

### **2013 Lyons Recovery Action Plan**

The *2013 Lyons Recovery Action Plan* was written and implemented in hopes of helping the town recovery and to promote resiliency. From guiding principles to help the entire town recover to individual goals for communities, this is the most comprehensive recovery plan in the town of Lyons' history. The driving principle behind this plan is to have as much community participation as possible, or several different working groups that come together to help bring the town back from the brink. Another important goal was to improve the town of Lyons' resiliency to future floods and other hazards to diminish future risks.

While meant to extend the goals identified in the *2010 Town of Lyons Comprehensive Plan*, it has future objectives that have changed since the 2013 floods. As mentioned above, this plan is so different from previous legislation because of the working groups that citizens created to help take control of their town's recovery. These Recovery Working Groups include: Housing, Stream Recovery, Public Facilities and Infrastructure, Parks and Recreation, Arts, Culture, and Historic Preservation, Business and Economic Development, and Health and Human Services groups. These groups were all impacted by the floods, and all had policies that were implemented due to the floods. These groups created "project development goals", and with the help of FEMA, helped to implement the strategies directed in the plan. The Town adopted this plan on March 31, 2014 (Lyons Recovery 2013).

In terms of the Health and Human Services goals, the biggest overshadowing idea was, "to identify important human services that may have been missing before the floods that would help protect vulnerable residents in the event of future disasters" (Lyons Recovery, 2013, p. 42). This means Lyons was hoping to create a better future, and not simply go back to the way things were pre-flood.

While every aspect of the plan is important, housing policies that changed due to flooding were particularly pertinent. Housing seems to be where most of the difficulty lies in terms of people returning to their homes as well as extended building in the town of Lyons. Even before the floods, there was a lack of affordable housing; after the floods, there is even more of a gap between people that can afford to live in Lyons and residents that will not be able to return because their home was destroyed.

These goals are similar to the *2010 Town of Lyons Comprehensive Plan* because one of the most vital goals in the plan was to streamline and help promote consistency in the regulatory review process. A large part of this portion of the plan was promoting strong resiliency objectives in terms of building homes. This means there needed to be a constant source of expertise and knowledge for people that were unsure of building, rebuilding, or had other questions about housing.

The most important goal within the housing objective being to “promote safe, stable, diverse neighborhoods and increase affordable housing” (Lyons Recovery, 2013, p.58), highlights the change from this plan compared to previous plans. This is so crucial because it includes changing the land use policies around housing. Housing objective 1.2.1 is meant to “evaluate and modify existing regulations and codes regarding construction of residential structures in floodplain areas” (Lyons Recovery, 2013, p. 58) This is the goal that will help to modify the building requirements to help ensure Lyons’ safety in terms of living in the floodplain and is especially geared towards new development.

Infrastructure was also gravely impacted by the floods. One of the lasting goals of this plan in terms of infrastructure was to create a long-term plan that established a culture of resiliency and sustainability. This plan hoped to update the Long Range Water Plan, Master



Wastewater Plan, and the Storm Drainage Master Plan, in hopes of advancing the knowledge gained from the flood to reduce damage that could be caused by future flooding.

An emergency alert system is a vital improvement in the Lyons flood warning system. Before the floods, Lyons had a minimal emergency response system that would deflect to Boulder County Emergency Services after 5pm (Lyons Recovery 2013). With this plan, there would be a multi-tiered emergency response system centered in the town of Lyons. This would give Lyons the chance to have full independence and responsibility as it moves forward in its resiliency planning.

Mentioned above are why affordable housing and infrastructure are important centers for mitigation, but parks and recreational areas are another fundamental resource in restoring and expanding resiliency. As they are an important buffer in terms of flooding, and also add great value to the town, this plan hopes to implement floodplain regulation in the reconstruction of the town's parks, including Meadow and Bohn park (Lyons Recovery 2013).

All of these aspects of the plan are interconnected, and together can combine a great mitigation plan to protect against future flooding. Incorporating floodplain management for the streams is a crucial part of development. The goals brought forth for the stream include creating and reestablishing natural habitat to protect against erosion and vegetative loss that can contribute to debris and increase in flow velocity. Reinforced hazard mitigation plans are also in motion to help establish a cleaner and smoother river corridor to protect against higher water flows and velocities seen during times of flood (Lyons Recovery 2013).

Channelization occurred on the St. Vrain when the flood caused new channels to be created and in turn caused damage to housing existing within the floodway. New channelization will help the water flow through the original channel and establish a deeper channel that will

abate the water from flowing out of the original channel. Retention ponds are another course of action to help mitigate flooding and are an important option for Lyons to consider (Lyons Recovery 2013).

This plan is still being implemented and will be crucial in helping the town establish resiliency and autonomy in its recovery from the 2013 flood event. As demonstrated in figure 9, there are several steps in the full implementation of this plan. What makes this plan different is that it really drives home how the people of Lyons did not want flooding to change their town the way it has before, there is an air of determination and perseverance to make true change, that has not been seen in previous plans.

	Timeframe			Recommendations		Resources Needed \$ < \$250k \$\$ = \$250k-\$1M \$\$\$ = \$1M- \$3M \$\$\$\$ > \$3M	Responsible Party	Key Partners	PDG	2010 Comprehensive Plan Reference
	2014	2015	2016	Priority a=Vital b=important c=desirable	Directly Flood-Related					
Stream Goal 2: Protect the natural and built environment from flood events and other hazards along the St. Vrain River.										
Stream Objective 2.1: Reinforce hazard mitigation techniques to accommodate increased water capacity and velocity from flooding and run-off, recreational, and flood mitigation benefits.										
STR 2.1.1: Mitigate high water mark debris and sediment deposits.	X	X		a	X	\$\$	Town Staff	SRTF	STR-4	
STR 2.1.2: Mitigate highway 36 CDOT bridges near the Planet Bluegrass property.	X	X		a	X	\$\$	Town Staff	SRTF	STR-2	
STR 2.1.3: Mitigate channelization of the North St. Vrain from 5th Ave to confluence.	X	X		a	X	\$\$	Town Staff	SRTF	STR-5	
STR 2.1.4: Develop detention and retention units on South St. Vrain Creek to Boulder County Open Space as a means of flood mitigation.	X	X	X	b	X	\$\$\$	SRTF	EB / Town Staff / SFC	STR-10	
Housing Goal 1: Recognize and accommodate the housing needs of a diverse population.										Housing Goal 1
Housing Objective 1.1: Encourage and facilitate the rebuilding of the Lyons housing stock and the return of residents displaced by flooding.										
HOU 1.1.1: Create a data base of residents who were displaced and homes that were destroyed.	X			a	X	\$	HSTF	Town Staff	HOU-3	
HOU 1.1.2: Expedite the regulatory review process.	X			a	X	\$	Town Staff	BOT	HOU-3	
HOU 1.1.3: Leverage volunteer efforts and technical expertise to assist with reconstruction/rebuilding efforts.	X	X		a	X	\$	Town Staff / LOV	HSTF	HOU-3	
HOU 1.1.4: Create temporary RV access for displaced residents.	X			a	X	\$	HSTF	Town Staff	HOU-8	
Housing Objective 1.2: Promote safe, stable, diverse neighborhoods throughout Lyons that provide a range of housing options and link residents to destinations to learn, work and shop.										Housing Objective 1.1
HOU 1.2.1: Evaluate and modify existing regulations and codes regarding construction of residential structures in floodplain areas.	X			a	X	\$\$	BOT	Town Staff	HOU-7	
Housing Objective 1.3: Increase opportunities for affordable housing.										
HOU 1.3.1: Encourage the development/construction of housing that is affordable by: a) virtue of the lot size, regulatory incentives, construction methodology and material usage, density; b) the use of financial subsidy and volunteer contributions.	X	X	X	a	X	\$\$	HRTF	PCDC / LOV	HOU-1 & HOU-6	
Infrastructure Goal 1: Provide adequate, safe and efficient public utilities.										Town Services Goal 1
Infrastructure Objective 1.1: Ensure that the Town has a long-term plan for improving resiliency of water, wastewater and electrical services to residents and businesses in Lyons' planning area.										
INF 1.1.1: Update the Long Range Water Plan, the Master Wastewater Plan and the Storm, Drainage Master Plan to reflect the Town's existing conditions and expanded planning area. Develop a master plan for the electric utility.	X	X		a	X	\$\$	UEB	Town Staff	INF-3, INF-6 & INF-8	Town Services 1.1.1
INF 1.1.2: Incentivize the implementation of energy efficiency and renewable energy measures to create resilient and sustainable energy distribution. <b>* INF-5 Developed by Housing RWG</b>		X	X	b	X	\$\$	SFC	UEB / PCDC	INF-5*	Town Services 1.2.1
Infrastructure Objective 1.2: Keep Lyons safe and secure.										Town Services Objective 1.2
INF 1.2.1: Update the All Hazard mitigation Plan & seek/secure funding for the Plan update and purchase of equipment. <b>* INF-2 Developed by Housing RWG</b>	X			a	X	\$	Town Staff	BOT / LFPD / BCSO	INF-1 & INF-2*	Town Services 1.2.2

**Figure 9.** Outline of the *Town of Lyons Recovery Action Plan*, and the three priorities discussed above. All of these sections were directly related to the flood, and most of them were prioritized to be completed in 2014 (Lyons Recovery 2013)

## 2014 Living With the Saint Vrain report

Within the *2013 Lyons Recovery Action Plan* was the important aspect of community involvement. Through the Recovery Working Groups, the community members of Lyons were able to help establish and drive the direction of the town's recovery. *Living With the Saint Vrain* helped take these working groups to the next level. This plan, established on October 31, 2014, was created with the assistance of the American Planning Association through its Community

Planning Assistance Teams (CPAT) program. “The Purpose of the CPAT initiative is to serve communities with limited resources by helping them address planning issues such as social equity and affordability, economic development, sustainability, consensus building, and urban design” (Community Planning, 2014, p.3).

The governmental aspects of this plan include input from the town of Lyons, the state of Colorado, the CPAT team, and FEMA. The outcomes of this plan are to help the town of Lyons form policy recommendations, best recovery practices, and design-based planning options as the Town continues its long term flood recovery. The two biggest observations for future planning include understanding the positive and negatives of living next to a river, and within this observation, understanding the risks and responsibilities of living within a floodplain (Community Planning 2014).

There are several different mitigation techniques used in the observations of these two planning options. For the purpose of this investigation, the land use planning goals were of the upmost importance. But just as with every other plan established in this investigation, every part of the recovery process is interconnected. This plan suggests an adoption of higher floodplain management standards. This includes moving current and new development away from the immediate floodway, as well as curbing development within the floodplain, and restricting building of critical facilities in the floodplain (Community Planning, 2014, p.5).

Housing has been a major theme of this investigation, and this plan establishes framework for a housing reconstruction strategy, or the first implementation of the voluntary “buyout” program. Due to unavailability of affordable housing, in early 2014, 310 families were still without homes, meaning 145 households were left empty for months after the flooding had subsided (Community Planning, 2014, p.11).

Alongside a lack of affordable housing is the fact that Lyons has reached its capacity for safe building, and that there are only a few parcels located outside of the floodplain left for development. Since the town of Lyons is sandwiched between Boulder County Open Space land and the floodplain, there is a limit on what land can be developed, and the lands that can be developed are also usually too expensive for the town of Lyons, or individual households to purchase (Community Planning 2014)

This plan helps to point out the problem of affordable housing and how to best live within the St. Vrain floodplain. There has been a definite push from the people of Lyons to take control of their own floodplain management. However, what is an even greater reality is that Lyons cannot help itself. With the annual budget of the town being \$1.2 million, and the recovery effort estimated at way above that, the town of Lyons depends on other organizations to help it reconstruct (Obrien). The plan helps to establish how communities can best help themselves. It was created to help give Lyons the independence it craved after its funds ran out. This plan is essential in helping gear the Lyons Recovery Plan into success as well as creating a community where citizens have a direct say and input into where they live.

Looking back through the history of floodplain management for the United States identified where and why floodplain management exists. Understanding where the town of Lyons is located helps to highlight why Lyons is a hotspot for flooding, and finally; going through the history of floodplain management for the town of Lyons creates a portfolio of methods tried in the past. All of these help to create opportunities for future recommendations discussed below.

## **Future Recommendations**

With the evolution of the floodplain management policies of Lyons, Colorado, the town has come a long way. In the past 40 years, there has been vast improvements in how people see flood interactions and how we recover from mass water events. The most influential legislation above is the *2013 Lyons Recovery Action Plan* and the *2014 Living With the Saint Vrain* report.

### **Cooperative Approach**

One of the main themes throughout the entire history of the town of Lyons' floodplain management is becoming a cooperative community that is in charge of their own decisions and growth. With Lyons' budget often smaller than the overall money needed to make true change (Community Planning 2014), the Community Planning Assistance Teams and Recovery Working Groups are crucial in keeping Lyons on track while minimizing budget changes. With this comes the independence that Lyons residents crave. This can be seen through the *2014 Living With the Saint Vrain Report*, when creating an emergency action plan centered in Lyons was a top priority. This cooperative work will help establish a sense of community and help neighbors care for each other in terms of establishing flood preventative measure and during a flood.

While there are already studies underway to update the latest flood rate insurance maps, greater delineation between the floodplain and floodway are crucial in helping identify the areas of greatest concern. In the latest flood, the town of Lyons was cut into several sections based on the change in channelization during the flood of 2013. Currently, based on the *2013 Recovery Action Plan* there is channelization of the stream in progress which will create space for water volume in case of massive rain events. This channelization will help reduce the chance of breaking up the town. The identification and further enforcement of the floodway, which is

prohibitive to build in, will help create a lasting culture of safety, as there will be an established line of where the most dangerous areas are located.

### **Housing**

Housing is another area in which several opportunities for improvement exist. There is seemingly no land to build on in Lyons that is outside of the floodplain. Whether due to the geography of the land outside of the floodplain, ownership of land by Boulder County Open Space, or the expense of the land, affordable housing is nearly impossible to find in Lyons. The result is 10 percent (Illescas 2015) of the population are not able to return after the flood because of a lack of affordable housing. Lyons is participating in a buyout program which can be seen in the Confluence neighborhood, but the extent and impact of the buyout program has yet to be seen on the economy of the town. Also, since only patchwork lots have been purchased, what the leadership of the town of Lyons is going to do with the buyout lots has yet to be seen. Even with the unknown, given the choice and economic support of either floodproofing their homes or buying out is a great start to ensuring greater resiliency within the community.

This study recommends further investigations into extending affordable housing for future and current residents. As the median income for the population of Lyons is relatively low at (\$65,656) (Lyons 2015), and the cost of housing is extraordinarily high, it makes for an imbalance in the economic diversity and inclusion of the town. Recently, as per the vote of the town, park and recreation lands were not implemented as suitable for affordable housing, leaving leadership with a difficult decision on the future of its residents and its current priorities (Illescas 2015).

Furthering this dilemma is one of the two mobile home parks was purchased through the buyout program, leading to even stronger strangulation on affordable housing (Lyons 2015). This

is a conundrum that needs to be investigated and evaluated immediately. As one of the main goals of the town is to have a more inclusive and diverse community that is open to future growth, safe and affordable housing is a crucial in creating the space for the goals to become realities. Also, giving nearly 10 percent of the population the ability to return to their homes will help the town to progress both in terms of housing and economically speaking (Illescas 2015).

Within this housing debate are the structures that have managed to be grandfathered in to current building regulations without having to be updated. As the community decided that working together is an important goal, having all of the homes set up to survive at least the 100-year flood will reduce injuries due to flooding, recovery time, and money. Creating legislation that supports flood roofing and floodplain management tactics into housing structures built before 1975 will help create a community focused on resiliency and create a standard of floodproofing and excellent floodplain management.

#### **Further floodplain management practices and warning systems**

My final recommendation is for continued work on a long-term emergency flood warning system. Combined with the above tactics in regards to housing regulations, a warning system can help save people's lives. Apart of the Recovery Action Plan is an emergency response system that is autonomous to Lyons, including a warning siren. This siren could help prevent people from moving around during floods or help people reach the emergency management center (Lyons 2013), before it is too late. Also, while Lyons remains under the Operation of Emergency Management located in the city of Boulder, there will be a lack of warning no matter what system is implemented. Current flood warning systems mainly rely on flood gage data. This does not give much time to really do anything in terms of movement or prevention, seemingly being ineffective. While flood warning systems are still developing all over the world, improving



research in this flood-prone area will give important data on how to improve systems and save lives. As displayed in Figure 11, there is distinct overlap between the floods that the town of Lyons has experienced and the recommendations produced after.

While the above recommendations do not necessarily give direct improvements for the town of Lyons, they do help to highlight how inclusive and extensive floodplain management is. Overall, my recommendations lend a hand to how improved, holistic, floodplain management could help the town of Lyons become an adaptable community.

## **Conclusions**

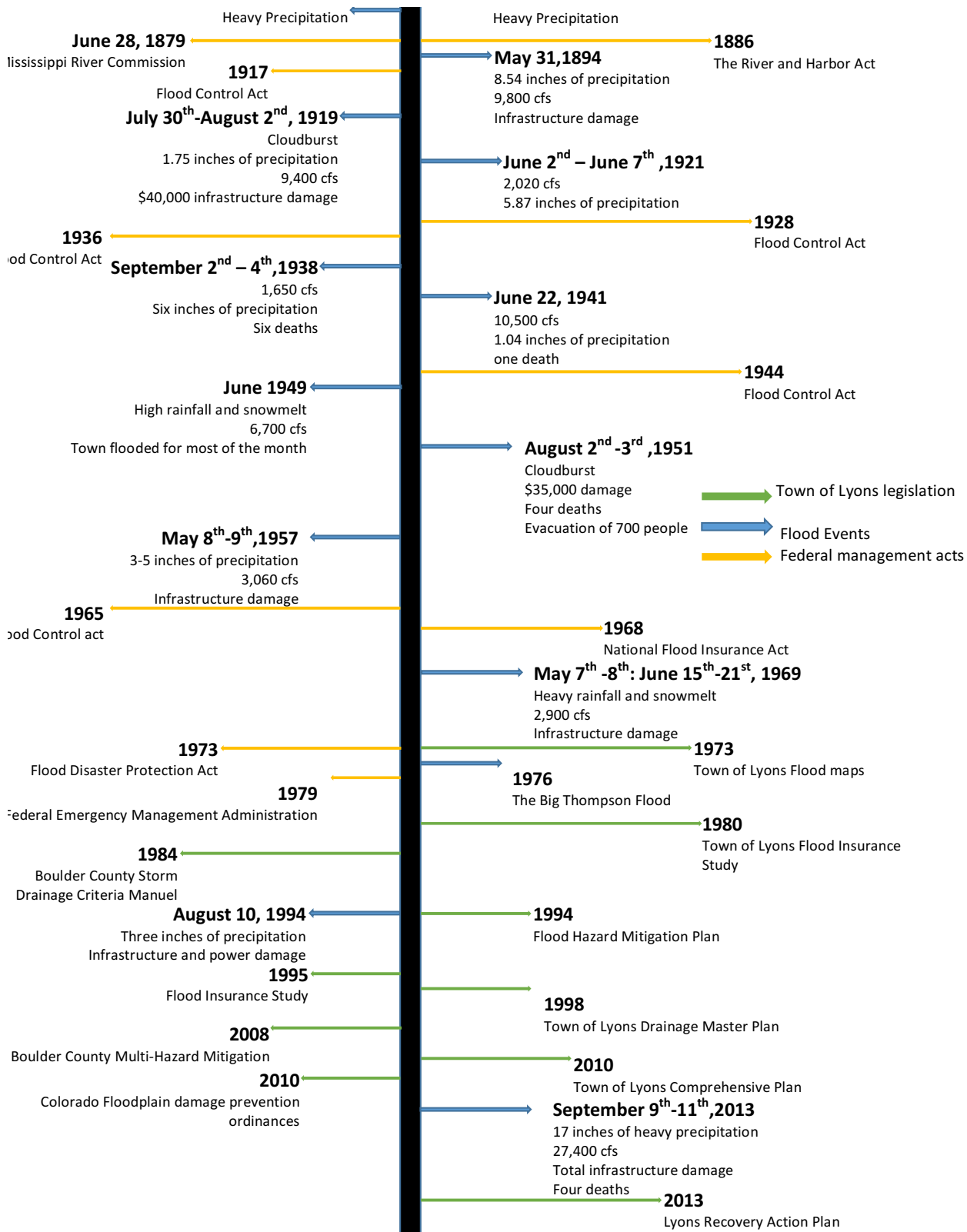
This investigation brought to light several gaps in the research of historical hydrology and socio-hydrology. By identifying how behavior is changed in the face of flooding and how history can help shed new light into the future, this investigation identifies gaps in past floodplain management legislation and conveys new recommendations for the town of Lyons.

Through the description and analysis of past floodplain management legislation, not only for the town of Lyons, but for national floodplain management, gaps were identified as places for further growth. Overall, this investigation suggests increased enforcement and advisement on legislation regarding future development and past construction. From this, there is the gleaming light of creating a community where each citizen has a say, in not only where they live but the management of the resources and land they are residing upon.

With a community that is active in floodplain management decisions, creating more affordable housing outside of the floodplain can hopefully be a problem that is solved with everyone's involvement. Living in a floodplain also comes a certain responsibility of creating a culture of resiliency and warning. The final recommendation given in this investigation is to promote further studies into a warning system that would save more lives and would also give

Lyons a sense of autonomy from the surrounding Boulder County, as well as a sense of control over where they live.

“We’ve Got Grit,” this phrase encapsulates Lyons in so many ways. The floods of 2013 completely destroyed the town and the lives of so many of its residents. However, as this investigation demonstrates, Lyons is an incredibly resilient town, that has come back time and time again from the results of living in a floodplain. With the current legislation in place, and the goals of the town moving towards sustainability and resiliency, there seems to be a light that gives hope to future residence of the town of Lyons. This investigation promotes community interaction and future planning. There is no doubt that Lyons will become a role model to small towns flourishing and will lead communities in how to establish economic and community prosperity.



**Figure 10.** An overview of this investigation, detailing the paralleled reality of the history of flood events in Lyons, Colorado; the history of floodplain management in the United States; and the floodplain management of the town of Lyons.

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